Thermal Ion Transport on the Moon and the Formation of the Lunar Swirls

The bright "swirl" features observed on the lunar surface are generally associated with crustal magnetic anomalies. Prominent explanations that invoke these fields include: magnetic shielding in the form of a mini-magnetosphere, which impedes space weathering by the solar wind; magnetically controlled dust transport; and cometary or asteroidal impacts, that could result in shock magnetization with concomitant formation of the swirls. Here we consider another possibility in which the ambient magnetic and electric fields can transport and channel secondary ions produced by micrometeorite or solar wind ion impacts. We use a simplified model of the fields, which incorporates a two-dipole magnetic field model for Reiner Gamma, and typical solar wind conditions. We will present preliminarily results suggesting that ions created over significant regions of the lunar surface can be transported under the influence of local and interplanetary electromagnetic fields to narrow areas near areas of high crustal magnetic field strength. The flux of these focused ions may be of sufficient intensity to chemically process (or otherwise bleach) the surface leading to the formation of the high albedo component of the lunar swirls. The theory is appealing since through a lensing effect, it is possible that this flux is sufficient to overcome other space weathering processes which would otherwise tend to erase the features. Also, with relatively low energy ions, and consistent with the observed focusing, the ion gyro radii in the local magnetic fields is small enough to resolve the swirls.